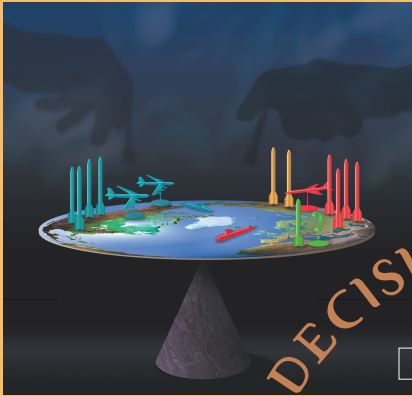


Seeking Strategic Stability

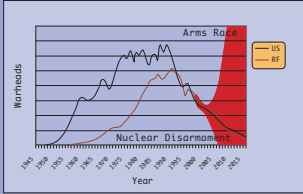


The MESA/SM computer program plays the strategic-force game. Only carefully crafted arsenals lead to strategic stability.

DECISION APPLICATIONS

Can the United States Ensure World Strategic Stability?

The answer depends on how accurately analysts can combine all the factors influencing strategic stability, a state achieved when no nation feels compelled to raise its level of alert or initiate nuclear war. For example, if superpower A changes its weapons mix by reducing nuclear arsenal, will superpower B agree to similar reductions? What if B refuses? What if nation C, an ally of A's less protected, as a result of A's reductions in strategic arsenal, and decides to develop or expand its own nuclear arsenal? Add into the mix rogue nation D that seeks to advance its own interests on the world stage. Would nation E fear attack from D and seek to enter the nuclear market as well? If superpower B decides to attack A and the latter retaliates, what physical, strategic, and human resources would remain undestroyed in these two countries; and how would other nations be affected?



Actual and Projected Strategic Warhead Levels

This graph tracks U.S. and Russian Federation (RF) strategic warhead levels from 1945 through 2015. Data are given through 1996 and are estimated for 1997 to 2001. Data for 2001 to 2015, shown in red, describe the region of possible, future strategic-warhead levels. MESA/SM uses such information to assess a given nation's ability to attack and counterattack.



The MESA/SM computer program (for Multiple Engagements of Strategic Arsenals with Stability Measures), which involves optimization and game theory, seeks answers to such questions. Developed at Los Alamos, this program models strategic nuclear forces to assess the adequacy and stability of the U.S. weapons stockpile. MESA/SM focuses on both strategic forces and alert levels. Analysts assign values to each variable in a scenario to find an optimal strategy for each nation, based on that scenario. Next, they assess that strategy's expected outcome. MESA/SM also calculates relative stability measures. It can determine whether a nation is more stable or less stable when it has more or fewer nuclear weapons or when it changes its level of alert. Such data allow U.S. political leaders to make necessary adjustments as world conditions change. Is the world more stable with more or with fewer nuclear powers? How would a national missile defense affect strategic stability? MESA/SM can address these significant questions.

Hierarchical Optimization

Given a system of K players, each with function f^i ($i = 1, \dots, K$), which is defined over a jointly dependent constraint set S , the objective of each player is to optimize the assigned function f^i :

optimize f^1 , where x^2 solves

$x^1 \in X^1$;

optimize f^2 , where x^3 solves

$x^2 \in X^2$;

.

optimize f^{K-1} , where x^K solves

$x^{K-1} \in X^{K-1}$; and

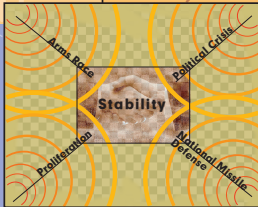
optimize f^K , where

$x^K \in X^K$

subject to $x = (x^1, \dots, x^K) \in S$.

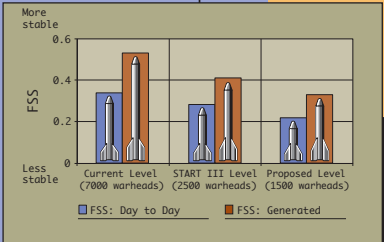
Hierarchical Optimization

The response of a player nation to a nuclear exchange depends on the attacker's strategy. Hierarchical optimization accounts for this dependency and calculates optimal war-fighting strategies for each player.



Risk to Strategic Stability

Illustrated here are four of the forces threatening world strategic stability. MESA/SM accounts for all except political crises.



Generating Forces on First-Strike Stability (FSS)

MESA/SM calculates 14 measures of relative strategic stability. Among them is FSS, which captures the player's relative advantages in being the initiator of hostilities. The FSS data are illustrated for the Russian Federation. Obtained with MESA/SM, these data cover three scenarios: current, projected START III, and proposed warhead levels. Two frequently modeled states of readiness are a day-to-day level—fewer warheads are available to fire—and a fully generated level—nearly all warheads are available to fire. According to these data, fewer warheads result in lower strategic stability.

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MILITARY SYSTEMS ANALYSIS AND SIMULATIONS



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